

MEDICAL APPLICATIONS OF AEROSPACE SCIENCE
AND TECHNOLOGY

QUARTERLY REPORT NO. 1
1 May - 31 July 1967

NASA Contract No. NASr-63(13)

MRI Project No. 3077-E

For

National Aeronautics and Space Administration
Office of Technology Utilization
Technology Utilization Division, Code UT
Washington, D. C. 20546

MIDWEST RESEARCH INSTITUTE

425 VOLKER BOULEVARD/KANSAS CITY, MISSOURI 64110/AC 816 LO 1-0202

N 67-34033

(ACCESSION NUMBER)

417

(PAGES)

CR-87407
(NASA CR OR TMX OR AD NUMBER)

(THRU)

(CODE)

05

(CATEGORY)

MRI

MEDICAL APPLICATIONS OF AEROSPACE SCIENCE
AND TECHNOLOGY

by

David Bendersky

QUARTERLY REPORT NO. 1
1 May - 31 July 1967

NASA Contract No. NASr-63(13)

MRI Project No. 3077-E

For

National Aeronautics and Space Administration
Office of Technology Utilization
Technology Utilization Division, Code UT
Washington, D. C. 20546



MIDWEST RESEARCH INSTITUTE

425 VOLKER BOULEVARD/KANSAS CITY, MISSOURI 64110/AC 816 LO 1-0202

PREFACE

This report covers the activities of the Midwest Research Institute's Biomedical Applications Team during May, June and July 1967. These activities were supported by NASA Contract No. NASr-63(13).

The work was directed by David Bendersky, under the general supervision of Mr. Paul C. Constant, Jr., Manager of Technology Utilization. Other MRI team members who contributed to the reported activities are James K. West and Dewey Garrett. Consultants from medical and bioengineering schools to this program are Dr. John W. Trank, University of Kansas Medical Center; Dr. William G. Kubicek, University of Minnesota Medical School; Dr. Alfred W. Richardson, Southern Illinois University; Mathew L. Petrovick, Northwestern University Medical School; Dr. Harry Ludwig, University of Wisconsin Medical Center; and Dr. James B. Reswick, Case Institute of Technology.

Approved for:

MIDWEST RESEARCH INSTITUTE

A handwritten signature in dark ink, appearing to read "Harold L. Stout". The signature is fluid and cursive, with the first name "Harold" being more prominent and the last name "Stout" following in a similar style.

Harold L. Stout, Director
Engineering Division

15 August 1967

TABLE OF CONTENTS

	<u>Page No.</u>
I. Introduction	1
II. Activities on Medical Problems	2
Electrocardiogram Electrodes, Medical Problem No. KU-1 . . .	2
Measurement of pH and Partial Pressure of Dissolved Gases in the Blood, Medical Problem No. KU-3	2
Respirometer Helmet, Medical Problem No. KU-5	2
Protective Clothing for Athletes, Medical Problem No. KU-7 .	3
Microtools for Ear Surgery, Medical Problem No. KU-10 . . .	3
Brain Lesion Device, Medical Problem No. KU-17	3
Measurement of pH of Colonic Content, Medical Problem No. KU-18	3
Fetal Electrocardiograms, Medical Problem No. KU-20	4
Photographic Techniques for Body Cavities, Medical Problem No. KU-21	4
Support for Ruptured Eardrums, Medical Problem No. KU-23 . .	4
Cardiac Output Measurement, Medical Problem No. KU-24 . . .	5
Blood Pressure Measurement, Medical Problem No. KU-25 . . .	5
Chronic Intracranial Pressure Measurements, Medical Problem No. KU-26	5
Ear Specimen Mounting Material, Medical Problem No. KU-27 .	6
Conversion of Biological Data, Medical Problem No. KU-28 . .	6
Muscle Accelerometer, Medical Problem No. SLU-7	6
Measurement of Blood Oxygen, Medical Problem No. SLU-8 . . .	7
Speech Spectrum Analyser, Medical Problem No. UM-4	7
Respiratory Air Flow Measurement, Medical Problem No. UM-6 .	7
Measurement of Bone Distortion, Medical Problem No. UM-8 . .	7
Microcirculation Measurement, Medical Problem No. UM-10 . .	8
Muscle Heat Measurement, Medical Problem No. UM-11	8
Electrocardiogram Zero Shift and Elimination, Medical Problem No. UM-12	8
Chest Wall Movement Measurement, Medical Problem No. UM-13 .	8
Methods of Water Extraction from the Environment, Medical Problem No. UM-14	9
Temporomandibular Joint Action Measurement, Medical Problem No. NU-1	9
Electroencephalogram Telemetry, Medical Problem No. NU-3 . .	9
Phonocardiograph Microphone, Medical Problem No. NU-4 . . .	9
Miniature Motors and Batteries, Medical Problem No. CI-1 . .	10
Joint Locks for Orthosis, Medical Problem No. CI-2	10

TABLE OF CONTENTS (Concluded)

	<u>Page No.</u>
Centrifuge Effects on the Cardiovascular System, Medical Problem No. CI-6; Modeling of the Heart Control System, Medical Problem No. CI-7; Effects of Posture on the Cardiovascular System, Medical Problem No. CI-8	10
Eyelid Closure Recording, Medical Problem No. UW-2	10
Miniature Equipment for Auditory Stimuli, Medical Problem No. UW-3	11
III. Miscellaneous Activities	11
References	13
Appendix I - Medical Problem Abstracts	16
Appendix II - NASA Tech Briefs	23

I. INTRODUCTION

The objective of this project is to transfer aerospace-generated technology to applications in the non-aerospace medical field. In the course of its concern with the well-being and functional capabilities of man in aerospace environments, the National Aeronautics and Space Administration has generated an extensive amount of science and technology pertaining directly to the field of medicine. In addition, the aerospace program has led to the development of technical innovations which may be applicable to the solution of medical problems. To accomplish the transfer of applicable science and technology from the aerospace program to the medical field, requires an orderly program of screening and evaluation of new aerospace developments.

The Midwest Research Institute Biomedical Applications Team was established at Midwest Research Institute in early 1965. This was a pioneering venture which required, first, the development of an effective system of operation. The system which was developed consists of four basic steps. The first step is the definition of specific medical problems. These problems are obtained from the professional staffs at selected medical and bioengineering schools. The second step is the identification of aerospace technology which offers potential solutions to the medical problems. This is done through literature searches, circulation of abstracts of the problems, the NASA Centers and aerospace contractors, and personal contacts. The third step is the evaluation of the identified aerospace technology. The evaluation is done by the staff at the school which submitted the medical problem. The final step is the dissemination of the information on successful transfers.

Six medical and bioengineering schools are presently associated with the MRI Biomedical Applications Team project. These schools are the University of Kansas Medical Center, Kansas City, Kansas; St. Louis University School of Medicine, St. Louis, Missouri; The University of Minnesota Medical School, Minneapolis, Minnesota; Northwestern University, Evanston, Illinois; The University of Wisconsin Medical Center, Madison, Wisconsin; and Case Institute of Technology.

The activities of the MRI Biomedical Applications Team during the period from February 1965 to May 1967 are reported in, "Medical Applications of NASA - Developed Science and Technology," Final Report, Contract No. NASr-63(03) and Quarterly Progress Report No. 4, Contract No. NASr-63(11). The present Contract No. NASr-63(13), covers the period from 1 May 1967 to 30 April 1968.

II. ACTIVITIES ON MEDICAL PROBLEMS

Electrocardiogram Electrodes, Medical Problem No. KU-1

The NASA electrodes, described in NASA TND-3414,^{1/} were continued to be used by Dr. Ronald M. Lauer's research group at the University of Kansas Medical Center to obtain electrocardiograms on children under exercise conditions, with good results. Most of the electrodes were applied by brushing the mixture on with a small paint brush. Dr. Lauer and his co-workers prepared a paper on the work they have done with these NASA electrodes. This paper has been submitted for publication in the Journal of Applied Physiology.

The commercial version of these electrodes, produced by the Houser Research and Engineering Company, Boulder, Colorado, was evaluated by Dr. Lauer's group. The first sample was found to be unsatisfactory because of drippage during application and clogging of the nozzle. These findings were reported to the Houser Company. A second sample was received from the Houser Company and evaluated by Dr. Lauer's group. Satisfactory results were obtained using the second sample.

Information on the NASA electrodes was requested by and furnished to Dr. W. Hobbings, Madison General Hospital, Madison, Wisconsin; Dr. T. Tarlo, Dalhousie University, Halifax, Nova Scotia; and C. Johnson, NASA Flight Research Center, Edwards, California.

Measurement of pH and Partial Pressure of Dissolved Gases in the Blood, Medical Problem No. KU-3

A paper by Woldring, Owens and Woolford^{2/} describes a process in which gases were sampled directly from circulating blood through a membrane at the tip of an intravascular cannula that was connected to the analyzing section of a mass spectrometer. This technique appears to be a solution to Medical Problem No. KU-3. A copy of this paper was sent to Dr. Lauer, University of Kansas Medical Center, for evaluation.

Respirometer Helmet, Medical Problem No. KU-5

The respirometer helmet, described in a previous report,^{3/} has continued to be successfully used at the University of Kansas Medical Center to collect exhaled breath for O₂ analyses.

A sample helmet was displayed at the Conference on Aerospace Related Technology for Industry and Commerce, Lewis Research Center, Cleveland, Ohio, 25 May 1967.

The Piper Brace Sales Corporation, Kansas City, Missouri, is considering the commercialization of this respirometer helmet.

Protective Clothing for Athletes, Medical Problem No. KU-7

A thermoplastic rubber material,^{4/} developed at the Jet Propulsion Laboratory, was investigated as a possible solution to Medical Problem No. KU-7, the protection of athletes. A patent application filed on this invention has been assigned to the California Institute Research Foundation. Information received from the California Institute Research Foundation indicates that the material is not adaptable for application to the human body and, therefore, cannot be used in this manner to protect the body.

Microtools for Ear Surgery, Medical Problem No. KU-10

A micromanipulation tool is described in NASA Tech Brief 67-10004,^{5/} Appendix II, which may be applicable to ear surgery, as required in Medical Problem No. KU-10. A copy of the Tech Brief was forwarded to Dr. F. Kirchner, University of Kansas Medical Center, for evaluation.

Brain Lesion Device, Medical Problem No. KU-17

An experimental model of the brain lesion device previously described,^{6/} was assembled and tested. The test was made with a limited range frequency source, a high gain pick-up receiver, and a slide-screw tuner for matching the waveguide to the probe at the test frequencies. The results were negative, with no measurable energy transmitted from the probe. Further tests are planned using a wide range variable frequency source and a spectrum analyzer.

Measurement of pH of Colonic Content, Medical Problem No. KU-18

The "Heidelberg Capsule" distributed by the Meditron Corporation of America, New York, New York, is designed to measure and transmit the pH level of the gastrointestinal (GI) tract, as required by Medical Problem No. KU-18. The unit is a small encapsulated transmitter which is swallowed and transmits pH value continuously as it passes through the GI tract. Literature on this capsule was forwarded to Dr. J. Rhodes, University of

Kansas Medical Center. The information on this item was obtained as a result of a suggestion by Dr. S. W. Stein, NASA Ames Research Center.

Fetal Electrocardiograms, Medical Problem No. KU-20.

A search of the aerospace literature revealed a report by W. A. Welch^{7/} which appears to be applicable to Medical Problem No. KU-20. A data processing technique is described which eliminates maternal ECG and increases the signal-to-noise ratio of fetal electrocardiograms. A copy of this report was sent to Dr. A. S. Wolkoff, University of Kansas Medical Center, for evaluation.

Photographic Techniques for Body Cavities, Medical Problem No. KU-21

Dr. John Busser, Bioinstrumentation Advisory Council of the AIBS, in responding to Medical Problem Abstract No. KU-21, suggested that Dr. Howard Bolin, Pennsylvania Hospital, Philadelphia, may have a solution to the problem of photographing internal body organs. We contacted Dr. Bolin and received from him papers which describe his work on pelvic endoscopy^{8/} and internal color TV techniques conducted at the Cook County Hospital,^{9/} Chicago, Illinois. These references appear to be directly applicable to Problem No. KU-21, and copies were sent to Dr. Wolkoff, University of Kansas Medical Center, for evaluation.

We contacted Mr. Harvey Geller, Cancer Control Program, U. S. Public Health Service, as suggested by Helen Chiaruttini, to determine the status of their work on the development of fiber-optic camera devices. This information was received and forwarded to Dr. Wolkoff.

Support for Ruptured Eardrums, Medical Problem No. KU-23

Andrew E. Potter, NASA Lewis Research Center, submitted a suggestion in response to Medical Problem Abstract No. KU-23. A Teflon dam, placed next to the injured eardrum, is suggested as a means to assist the healing of the eardrum. The suggestion was forwarded to Dr. Kirchner, University of Kansas Medical Center, for evaluation.

A literature search of aerospace technology on materials which may be used as a support for ruptured eardrums was conducted. No aerospace literature relating to this problem was revealed.

Cardiac Output Measurement, Medical Problem No. KU-24

A literature search was conducted on aerospace technology which may be applied to the external measurement of cardiac output. Several pertinent reports were revealed in this literature search and copies of these reports were ordered for evaluation.

Recent communications from Dr. Kubicek, University of Minnesota, indicates that one of his cardiac output systems,^{10/} developed under partial NASA support, is expected to be available in September 1967, for evaluation at the University of Kansas Medical Center as a solution to this problem.

Blood Pressure Measurement, Medical Problem No. KU-25

At the University of Kansas Medical Center, there is a need to measure and record the blood pressure of a subject while exercising.

A blood pressure measuring system,^{11/} developed for the NASA Manned Spacecraft Center (MSC), was identified as a potential solution to this problem. A brief description of the system is given in Tech Brief 65-10365, Appendix II. A unit was obtained from MSC for evaluation at the University of Kansas Medical Center. Satisfactory results were obtained on several subjects. After several trials the system became inoperative and was returned to MSC. A new unit is expected to be sent from MSC 2 August 1967. The tests will be resumed when the new unit is received.

Chronic Intracranial Pressure Measurements, Medical Problem No. KU-26

There is a need, at the University of Kansas Medical Center, for a method of obtaining long term measurements of pressure inside the skull of live human subjects. An abstract of this problem, given in Appendix I, was prepared and submitted to NASA Headquarters for distribution. A literature search was conducted.

Two NASA items were identified as potential solutions to this medical problem. One item is a pressure telemetry system described in Tech Brief 66-10624, Appendix II, which was developed by the Ames Research Center (ARC). Data on the pressure cell used in the ARC system were obtained from the Electro-Optical Systems, Pasadena, California, which indicate that this transducer is applicable to the problem. These data were sent to Dr. Brackett, University of Kansas Medical Center, for evaluation.

The second NASA item identified as a potential solution to this problem is a pressure transducer developed at the Jet Propulsion Laboratory,

described in Tech Brief 67-10020, Appendix II. Detailed information received on this sensor indicates that the unit is too large to meet the requirements of this application. Further miniaturization of this sensor may be possible; however, this will not be undertaken until the Electro-Optical transducer is evaluated.

The Schaevitz-Bytrex Company manufactures transducers which appear to be applicable to this problem. Literature on these transducers were sent to Dr. Brackett.

Ear Specimen Mounting Material, Medical Problem No. KU-27

There is a need for an improved material for imbedding ear specimens for microscopic observation. A description of this problem was prepared in Medical Problem Abstract No. KU-27, given in Appendix I. Copies of this abstract were sent to NASA Headquarters for distribution. A literature search was conducted on this problem and three reports revealed in this search have been ordered for evaluation.

Conversion of Biological Data, Medical Problem No. KU-28

Medical researchers at the University of Kansas Medical Center are interested in a simplified method for converting biological analog data to digital data. A literature search on aerospace technology was conducted. The search revealed only one related reference, which has been ordered.

A conversation with C. Johnson, NASA Flight Research Center (FRC), indicated that a biological data conversion technique had been developed at FRC. A report of this technique was furnished by Mr. Johnson. This report has been forwarded to the University of Kansas Medical Center for evaluation.

Muscle Accelerometer, Medical Problem No. SLU-7

Information on the muscle accelerometer, previously described,^{12/} was sent to the following companies for commercial consideration: Automation Industries, Boulder, Colorado; Gulton Industries, Metuchen, New Jersey; Magnaflux Corporation, Chicago, Illinois; and the Vendo Corporation, Kansas City, Missouri. A negative reply has been received from the Magnaflux Corporation. The other companies have not yet replied.

Measurement of Blood Oxygen, Medical Problem No. SLU-8

A report entitled, "Wearable, Wireless Oximeter," NASA Accession No. N65-30480, describes an instrument for measuring blood oxygen, developed by the Beckman Company for the Ames Research Center. This instrument appears to be applicable to Medical Problem No. SLU-8. A copy of this report was sent to Dr. Richardson for further evaluation at St. Louis University.

Speech Spectrum Analyzer, Medical Problem No. UM-4

As a result of a brief article appearing in the April 1967 issue of Bell Laboratories Record, contact was made with M. R. Schroeder of the Bell Telephone Laboratories, Murray Hill, New Jersey, regarding his work on speech displays. Two reports^{14,15/} were received from Mr. Schroeder which describe methods to display the spectrum of a speech signal and a process to reduce the bandwidth of a speech signal and then reconstruct the signal to the original quality. Some aspects of this work may be applicable to Problem No. UM-4. Copies of these reports were sent to Dr. Kubicek, University of Minnesota, for evaluation.

Respiratory Air Flow Measurement, Medical Problem No. UM-6

Five reports,^{14-18/} revealed in the literature search on methods for measuring respiratory air flow, were received and evaluated. Reference 14 was found to be potentially applicable to Problem UM-6. Two flow meters, which work on thermodynamic principles, are discussed in^{14/}. Information on these flow meters is being forwarded to Dr. Kubicek, University of Minnesota Medical School, for evaluation.

Measurement of Bone Distortion, Medical Problem No. UM-8

NASA Tech Brief 65-10023, Appendix II, describes a miniature stress transducer, developed at the Jet Propulsion Laboratory, which is potentially applicable to the measurement of bone distortion. Information on this transducer was received from JPL and forwarded to Dr. Kubicek, University of Minnesota Medical School, for evaluation.

A paper^{13/} by Smith and Keiper describes work on the mechanical properties of bone specimens done at the Henry Ford Hospital, Detroit, Michigan. A personal communication from Dr. Smith indicates that although the technique has not been used in vivo, it should work for such applications.

A copy of the paper was sent to Dr. Kubicek, University of Minnesota Medical School, for evaluation.

Microcirculation Measurement, Medical Problem No. UM-10

A literature search was made on Problem No. UM-10. Several pertinent references were revealed. NASA Technical Note TN D-3497¹⁹ describes work done at the Ames Research Center on the analysis of blood flow in capillaries. Reports^{20,21} by P. I. Harris et al. describe techniques for the measurement and analysis of red blood cell movement in the microcirculation system. The paper²² by M. Intaglietta and B. W. Zweifach describes the measurement of the movement of red cells in capillaries from enlarged timed photomicrographs. Copies of these references were sent to Dr. Kubicek, University of Minnesota Medical School for further evaluation.

An abstract of this problem, given in Appendix I, was prepared and sent to NASA Headquarters for distribution.

Muscle Heat Measurement, Medical Problem No. UM-11

A literature search was conducted on Problem UM-11. Five reports were ordered and evaluated. None of these reports contained a solution to this problem.

Electrocardiogram Zero Shift and Elimination, Medical Problem No. UM-12

A literature search was made on Problem UM-12. Eight reports were ordered.

Medical Problem Abstract No. UM-12, given in Appendix I, was prepared and sent to NASA Headquarters for distribution.

Chest Wall Movement Measurement, Medical Problem No. UM-13

As a result of a literature search a paper²³ by C. M. Agress et al. describes an on-line signal averaging technique which was used successfully in recording cardiac vibration data during exercise. This work was conducted at the Cedars-Sinai Medical Research Center, Los Angeles, California, under a NASA grant. A copy of this paper was sent to Dr. Kubicek, University of Minnesota Medical School, for further evaluation.

Methods of Water Extraction from the Environment, Medical Problem No. UM-14

A literature search was conducted on Problem No. UM-14. A number of reports were ordered and are now being evaluated.

Temporomandibular Joint Action Measurement, Medical Problem No. NU-1

The evaluation of the Ames Research Center triaxial accelerometer, previously described,^{24/} at the Northwestern University Medical School for Problem No. NU-1 was delayed pending receipt of a new study grant.

Electroencephalogram Telemetry, Medical Problem No. NU-3

A telemetry system for obtaining electroencephalograms on several subjects simultaneously is required at the Northwestern University Medical School. This system is to be used in a study of the responses of children in a group environment.

The Ames Research Center's (ARC) EEG helmet system, described in NASA Tech Brief 66-10536, Appendix II, has been identified as a potential solution to this problem. George Edwards, ARC, was contacted to determine whether one of these helmets was available for evaluation. George informed us that one of these helmets is expected to be available at the end of this summer for evaluation at Northwestern University Medical School.

Nutronics, Inc., Minneapolis, Minnesota, manufactures a multi-channel EEG telemetry system which is a potential solution to this problem. Literature on this system was forwarded to Drs. Reid and Myklebust, Northwestern University Medical School, for evaluation.

Phonocardiograph Microphone, Medical Problem No. NU-4

Medical researchers at Northwestern University are involved in the development and evaluation of heart sound computer systems. They are currently evaluating phonocardiograph microphones for one of their heart sound systems.

NASA Tech Brief 66-10314, Appendix II, described a phonocardiograph microphone which was developed for the NASA Manned Spacecraft Center (MSC). Contact was made with Mr. W. Chymlax, MSC, and one of these microphones was sent to M. L. Petrovick, Northwestern University Medical School, for evaluation.

Miniature Motors and Batteries, Medical Problem No. CI-1

Summaries of government-supported research projects related to Problem No. CI-1, furnished by Smithsonian Institute Science Information Exchange, and data on a miniature battery produced by Bionetics, Los Angeles, California, were forwarded to Dr. Reswick, Case Institute of Technology.

A copy of the aerospace literature search previously conducted on this problem was requested by and furnished to M. Petrovick, Northwestern University.

Joint Locks for Orthosis, Medical Problem No. CI-2

Four NASA items were identified as potentially applicable to Medical Problem No. CI-2. These NASA items include a braking mechanism, described in NASA Tech Brief 66-10484; a solid-state circuit control, described in NASA Tech Brief 66-10486; a hydraulically controlled flexible arm, described in NASA Tech Brief 66-10626, and an adjustable hinge described in NASA Tech Brief 67-10056. Copies of these Tech Briefs, given in Appendix II, were sent to Dr. Reswick, Case Institute of Technology, for evaluation. Summaries of government projects related to this problem, furnished by the Smithsonian Institute Science Information Exchange, were also forwarded to Dr. Reswick.

The aerospace literature search on this problem was requested by and furnished to M. Petrovick, Northwestern University.

Centrifuge Effects on the Cardiovascular System, Medical Problem No. CI-6; Modeling of the Heart Control System, Medical Problem No. CI-7; Effects of Posture on the Cardiovascular System, Medical Problem No. CI-8

Literature searches were completed on Medical Problems Nos. CI-6, CI-7 and CI-8. A considerable number of aerospace reports were revealed in each of these literature searches. The results of these literature searches and six reprints of pertinent papers were sent to Case Institute of Technology for evaluation.

Eyelid Closure Recording, Medical Problem No. UW-2

A North American Aviation report,^{25/} describes eyeblink measurement techniques which may be applicable to Medical Problem No. UW-2. A copy of this report was sent to Dr. H. Ludwig, University of Wisconsin Medical Center, for evaluation.

Summaries of Government-supported projects related to this problem, furnished by the Smithsonian Institute Science Information Exchange, were also forwarded to Dr. Ludwig.

Miniature Equipment for Auditory Stimuli, Medical Problem No. UW-3

A student at the Kansas City Art Institute has developed a head-phone which may solve Medical Problem No. UW-3. A copy of his report,^{26/} was forwarded to Dr. Ludwig, University of Wisconsin, for evaluation. Mr. Holzaepfel worked on this problem as a result of discussions with members of the MRI Biomedical Applications Team.

III. MISCELLANEOUS ACTIVITIES

1. Evaluation reports on 17 NASA Center suggestions were prepared and sent to NASA Headquarters.

2. Dr. Kubicek requested a number of reference reports. These reports were ordered.

3. SDI report listings were sent to Drs. Kubicek, Richardson and Trank.

4. A paper^{27/} on the muscle accelerometer and the spray electrodes, prepared by D. Bendersky, has been accepted for presentation at the 7th International Conference on Medical and Biological Engineering, Stockholm, Sweden, on 18 August 1967.

5. A subject interest listing was submitted to the ASTRA Project. All pertinent aerospace reports will be screened by ASTRA personnel and forwarded to the Biomedical Applications Team for evaluation.

6. Up-to-date information on the walking wheelchair was obtained from Space General Corporation, El Monte, California, and the Rancho Los Amigos Rehabilitation Center, Downey, California. This item is of interest at the Northwestern University Rehabilitation Institute.

7. Dr. W. Ko, Case Institute of Technology, requested copies of progress reports on the MRI Biomedical Applications Team program. Copies of prior progress reports were sent to Dr. Ko and his name has been placed on the distribution list.

8. General information on the Biomedical Applications program was requested by and sent to Dr. Warren McGonnagle, Elmhurst, Illinois.

9. Information on MEDLARS literature search services was obtained from the National Library of Medicine.

10. An evaluation form was prepared and sent to each of the participating medical schools for use in reporting the evaluation of technology which is furnished by the Biomedical Applications Team. One of these forms is sent out with each reference.

11. Monthly Progress Reports Nos. 1 and 2, covering the activities in May and June 1967, respectively, were prepared and distributed.

12. A copy of AEC-NASA Tech Brief 67-10188, Appendix II, was sent to Dr. Brackett, University of Kansas Medical Center.

REFERENCES

1. "Dry Electrodes for Physiological Monitoring," by C. W. Patten, F. B. Ramme and J. Roman, NASA Technical Note, NASA TN D-3414, May 1966.
2. "Blood Gases: Continuous in Vivo Recording of Partial Pressure by Mass Spectrography," S. Woldring, G. Owens and D. C. Woolford, Science, 19 August 1967, pp. 885 - 887.
3. MRI Quarterly Progress Report No. 3, Contract No. NASr-63(11), Appendix III, 1 October - 31 December 1966.
4. "Thermoplastic Rubberlike Material Produced at Low Cost," NASA Tech Brief 66-10452, October 1966.
5. "Micromanipulation Tool is Easily Adopted to Many Uses," NASA Tech Brief 67-10004, January 1967.
6. MRI Quarterly Progress Report No. 2, NASA Contract No. NASr-63(11), Appendix VI, 1 July - 30 September 1966.
7. "Matched-Filter Processing of Fetal Electrocardiograms," by W. A. Welch, Catholic University of America, NASA Accession No. 66-15118, June 1966.
8. "Recent Advances in Pelvic Endoscopy," by Balin, Wau, and Isael, Obstetrics and Gynecology, January 1966.
9. "Color TV From Inside the Body," Science News, 3 June 1967.
10. "Development and Evaluation of an Impedance Cardiac Output System," by Kubicek, et al., Aerospace Medicine, December 1966.
11. Final Report, "Blood Pressure Measuring System 54803 Project Gemini," Contract No. NAS 9-2837, The Garrett Corporation Aerosearch Manufacturing Division, 7 April 1965, NASA Accession No. N65-29782.
12. MRI Quarterly Progress Report No. 3, NASA Contract No. NASr-63(11), Appendix IV, 1 October - 31 December 1966.
13. "Dynamic Measurement of Viscoelastic Properties of Bone," R. W. Smith and Keiper, American Journal of Medical Electronics, October - December 1965.

14. "Development and Testing of a Prototype Respiration Analyzer," Final Report, Phase II, NASA Contract NAS 4-367, by R. K. Breeze, North American Aviation, Inc., NASA Accession No. N66-23822, 25 January 1965.
15. "Studies of Circadian Cycles in Human Subjects During Prolonged Isolation in a Constant Environment Using Eight Channel Telemetry Systems," B. R. Clegg and K. E. Shaefer, U. S. Naval Submarine Medical Center, NASA Accession No. N66-32262, 10 February 1965.
16. "Preliminary Analyses of the Metabolic Rate Monitor System," Cambell, et al., NASA Contract NAS 4-876, North American Aviation, Inc., NASA Accession No. N66-37217, 1 July 1965.
17. "A Study of Man's Physical Capabilities on the Moon," by F. Larmie, Vol. I, Part 2, Instrumentation, Contract No. NAS 1-4449, Northrup Space Laboratories, NASA Accession No. N66-38795, July 1965.
18. "Results of Certain Electro-Physiological Investigations on the 'Vaskhad' Spacecraft," I. T. Akulinichen, et al., 165h Int. Astronautical Congress, NASA Accession No. N65-35785, October 1965.
19. "On the Dynamics of Capillaries and the Existence of Plasma Flow in the Pericapillary Lymph Space," J. T. Howe and Y. S. Sheaffer, Ames Research Center, NASA Technical Note TN D-3497, NASA Accession No. N66-32697, August 1966.
20. "Statistical Quantization of Erythrocyte Passage in Capillaries," P. D. Harris, Ph.D. Thesis, Northwestern University (1967).
21. "Detection of Erythrocytes Passing Through Capillaries by a Photocell," P. D. Harris, et al., Northwestern University (1965).
22. "Indirect Method for Measurement of Pressure in Blood Capillaries," M. Intaglietta and B. W. Zweifach, Circulation Research, July 1966.
23. "Signal Averaging Techniques for Chest Wall Vibration Recording," C. M. Agress, et al., Medical Research Engineering, First Quarter (1967).
24. "Medical Applications of NASA-Developed Science and Technology," Quarterly Progress Report No. 9, NASA Contract No. NASr-63(11), Midwest Research Institute, 1 January - 31 March 1967.
25. "Feasibility of Techniques for Monitoring Physiological Variables Without Attached Sensors," Final Report, NASA Contract No. NAS 12-1, North American Aviation, Inc., 4 November 1966.

26. "Equipment for Presentation and Response Determination of Auditory Stimuli," by J. Holzeapfel, Kansas City Art Institute, and Industrial Design Department (unpublished) (1967).
27. "A Muscle Accelerometer and Spray-On Electrocardiogram Electrodes," by D. Bendersky, to be presented at the 7th International Conference on Medical and Biological Engineering, Stockholm, Sweden, 18 August 1967.

APPENDIX I

MEDICAL PROBLEM ABSTRACTS

KU-26 Chronic Intracranial Pressure Measurement
KU-27 Ear Specimen Mounting Material
UM-10 Microcirculation Measurement
UM-12 Electrocardiogram Zero Shift Elimination

MEDICAL PROBLEM

May 1967

This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent applications may be made. Thank you.

No. KU-26

Chronic Intracranial Pressure Measurement

What is Needed: A miniature transducer for measurement of intracranial pressures.

Background: There is an interest in the long-term measurement of pressure inside the skull of a live subject. This measurement requires the use of a very small implantable sensor. The physical configuration of the transducer is very important. The maximum dimensions of the sensor are 3/16 in. diameter by 1/4 in. long. The unit should be sufficiently sensitive over a range of 0 to 13.3×10^3 dynes/cm² gage (0 to 0.2 psig). The transducer could be a differential or absolute pressure reading type.

The placement of the transducer would be in the area between the lower surface of the skull and the lining of the brain. The wires would be routed through an access hole in the skull, which would require sealing after the transducer was in place. The cable could be attached through a miniature connector. The connector could be mounted on the skull by use of a small bone screw.

The transducer element could be a strain gage (metal or semiconductor) or another configuration such as variable inductance, or reluctance. A differential transformer also could be used. An alternate method would be to use a single channel telemetry device. This could be accomplished by having the pressure element as an active part of the telemetry circuit. In using a telemetry module, the electronic package would be mounted external to the skull.

Combination of a miniature externally mounted pressure transducer, and the telemetry package would be a feasible approach. A pilot tube would run from the sensor through the access hole and into the desired area. The tube must be sealed for proper operation.

Source of Problem: Dr. Charles Brackett, University of Kansas Medical Center, Kansas City, Kansas.

PREPARED FOR NASA

BY

MIDWEST RESEARCH INSTITUTE

425 VOLKER BOULEVARD / KANSAS CITY, MISSOURI 64110 / AC 816 LO 1-0202

MEDICAL PROBLEM

June 1967

This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent applications may be made. Thank you.

No. KU-27

Ear Specimen Mounting Material

What is Needed: An improved imbedding material for the preparation of thin samples of inner ear specimens.

Background: In microscope observations of biological specimens, a very thin sample is required. The cutting of the specimen is done by an instrument called a microtome. The biological specimen must be made comparatively rigid prior to cutting, by imbedding the specimen in a hard plastic or by freezing.

In the preparation of inner ear specimens (tissue and bone) epoxy is being used as the imbedding material. The specimen is placed in a mold and the epoxy forced into the voids in the intratissue and bone spaces. After the plastic hardens the specimen is removed from the mold and is cut into thin samples on the microtome. Freezing is not applicable to inner ear specimens because it causes distortion.

The epoxy now being used as imbedding material is unsatisfactory because the material is hard, making it difficult to cut thin sections. Furthermore, the hardness of the epoxy varies.

The desired material should be capable of being diffused into the specimen voids and intratissue spaces, harden by catalytic means, have a consistency similar to soft bony tissue, clear, colorless, non-shrinking, fast curing, and allow easy cutting on a microtome without specimen deformation.

Source of Problem: Dr. Fernando Kirchner, University of Kansas Medical Center, Kansas City, Kansas.

PREPARED FOR NASA

BY

MIDWEST RESEARCH INSTITUTE

425 VOLKER BOULEVARD / KANSAS CITY, MISSOURI 64110 / AC 816 LO 1-0202

MEDICAL PROBLEM

May 1967

This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent applications may be made. Thank you.

No. UM-10

Microcirculation Measurement

What is Needed: A method to accurately measure blood flow in the capillary beds of the microcirculation.

Background: Blood flow in the major arteries and veins can be measured directly with an electromagnetic flow meter to give information about the total blood flow to a particular region of the body. However, these measurements are inadequate because many cardiovascular diseases and cardiovascular drugs effect changes in the microcirculation which do not reflect any detectable change of flow in the major arteries and veins. Methods for measuring blood flow in the large vessels have not been successful when applied to the microcirculation.

This problem stems from the fact that the capillary vessels are quite small (diameters of 5-30 microns) and are an integral part of living tissue. In addition, the blood flow is intermittent and may sometimes reverse direction. Recently, a visual particle velocity meter was used to measure the mean velocities of blood in arterial vessels.^{1/} These vessels had diameters of 65, 40, 17 and 9 microns with mean velocities of 6.2, 4.5, 3.2 and 1.8 mm/sec, respectively. Other methods for determining blood flow in the microcirculation involve (1) direct measurement of capillary pressure through a micropipette inserted into the capillary lumen, and (2) indirect measurement of capillary pressure by measuring the force necessary to cause collapse of cutaneous capillaries. Flow was then calculated on the basis of the capillary pressure and diameter. However, the results are both erratic and difficult to interpret because the capillary diameter is constantly changing.

Capillary flow rates have been estimated to be 0.5 mm/sec. Other parameters which may be useful for developing methods to measure blood flow in the microcirculation are tabulated below:

^{1/} Berman, H. J. and R. L. Fuhro. Velocity Profiles in Small Blood Vessels. Federation Proceedings Abstracts, Vol. 26, No. 2, p. 496, Abstract No. 1335. March, April, 1967.

PREPARED FOR NASA

BY

MIDWEST RESEARCH INSTITUTE

425 VOLKER BOULEVARD / KANSAS CITY, MISSOURI 64110 / AC 816 LO 1-0202

MEDICAL PROBLEM

This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent applications may be made. Thank you.

Medical Problem

Microcirculation Measurement

May 1967

No. UM-10

Page 2

	<u>Outside</u> <u>Dia. (micron)</u>	<u>Wall Thick-</u> <u>ness (micron)</u>	<u>Length (mm)</u>	<u>Pressure</u> <u>(mmHg)</u>
Small Artery	20-25	5-6		
Arteriole	18-20	3-4	2.0	85-35
Metarteriole	14-16	2-3		
Precapillary Sphincter	10-12	1-2		
True Capillary	5-10	1	0.5	35-15
Venule	20-30	4-5	2.0	15-6
Small Vein	30-50	6-8		

Source of Problem: Dr. William G. Kubicek, Professor of Physical Medicine, University of Minnesota Medical School.

PREPARED FOR NASA

BY

MIDWEST RESEARCH INSTITUTE

425 VOLKER BOULEVARD / KANSAS CITY, MISSOURI 64110 / AC 816 LO 1-0202

MEDICAL PROBLEM

April 1967

This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent applications may be made. Thank you.

No. UM-12

Electrocardiogram Zero Shift Elimination

What is Needed: A method to eliminate the zero shift in the electrocardiogram (ECG) signal during exercise.

Background: Immediately prior to each mechanical contraction of the heart an electrical impulse is initiated. This impulse travels from the heart's pacemaker, down a transmission line and into the cardiac muscle fibers. It is this spread of electrical currents through the surrounding tissues of the heart that we term the electrocardiogram signal. The signal may be picked up and recorded by the use of specially placed electrodes and sufficient amplification.

The ECG waveform is made up of several spectral parts. There is a group of high frequency components due to the electrical activity of the heart, and a much lower frequency signal which is known as zero or base line shift. This shift is not related to the cardiac function, but is an unwanted artifact signal. It is believed that this artifact signal is actually the sum of several other biological signals, such as electrode, chemical, and muscle voltages. Due to the construction of electrodes (metal to tissue interface) they often act as small voltage cells. The voltage generated can be changed as a result of electrode displacement and locally produce body chemicals. This voltage can show up as a part of the ECG signal. The chemical flow of body electrolytes can also produce an artifact signal in the ECG. In recording ECG waveforms during exercise, many muscles are brought into play. The voltage generated by these muscles are often integrated into the cardiac waveform.

The spectral separation point between the artifact and the ECG signal is about 1 cps. Generally, there is some overlapping of the signals. This eliminates the use of simple, high-pass filtering techniques.

Figure 1 shows samples of actual electrocardiogram waveforms. Graph (A) is of a normal tracing and waveform (B) exhibits the slow wave artifact voltage. The peak-to-peak amplitude of the average ECG signal is about 1.0 millivolts. The interval between beats is in the order of 0.5 to 2.0 sec.

Source of Problem: Dr. William G. Kubicek, Professor of Physiology, University of Minnesota Medical School.

PREPARED FOR NASA

BY

MIDWEST RESEARCH INSTITUTE

425 VOLKER BOULEVARD / KANSAS CITY, MISSOURI 64110 / AC 816 LO 1-0202

MEDICAL PROBLEM

This problem abstract is designed to call to the attention of NASA personnel (and others who have agreed to participate) significant barriers that impede the progress of biomedical research and health care. The purpose is to bring to bear on these problems the expertise that resides in NASA. If you feel you can make a contribution, please communicate your suggestions to the Technology Utilization Officer at your installation. Also, alert him to any suggestions which can constitute inventions so that patent applications may be made. Thank you.

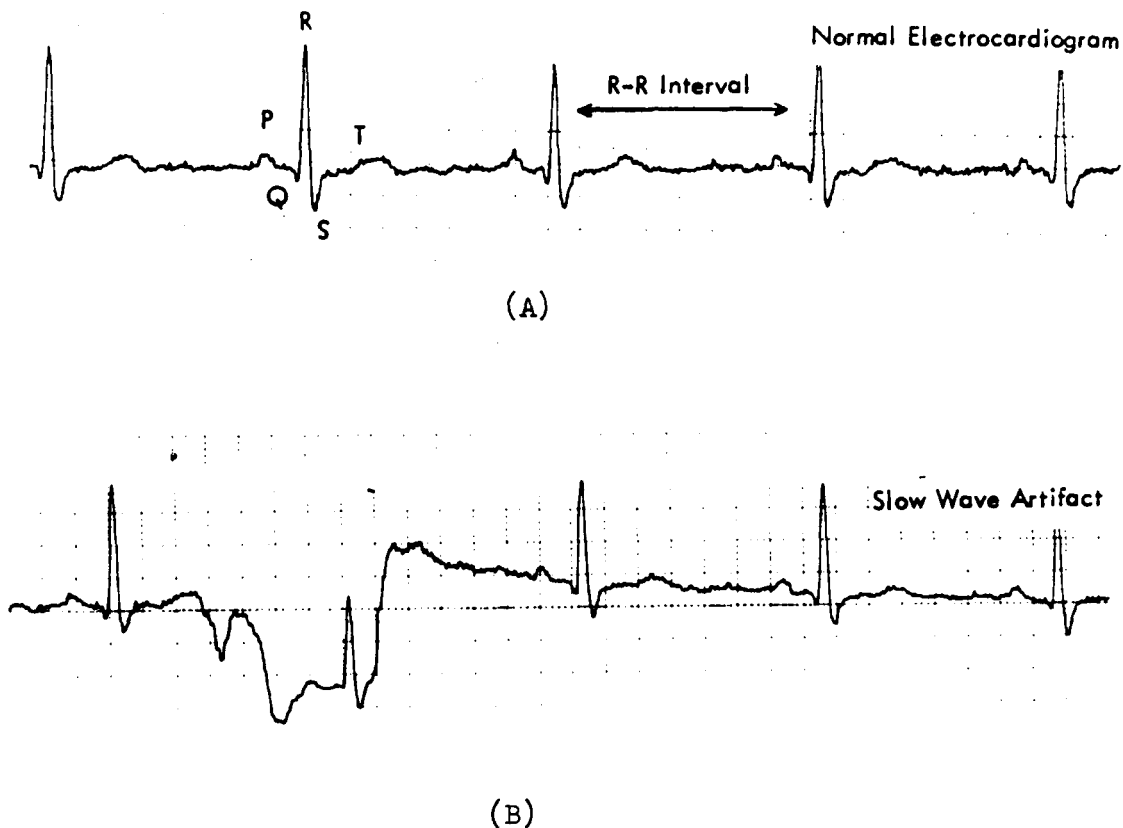


FIGURE 1. SAMPLE ELECTROCARDIOGRAM

PREPARED FOR NASA

BY

MIDWEST RESEARCH INSTITUTE

425 VOLKER BOULEVARD / KANSAS CITY, MISSOURI 64110 / AC 816 LO 1-0202

APPENDIX II

NASA TECH BRIEFS

65-10023

66-10314

65-10365

66-10624

67-10020

67-10056

66-10626

66-10486

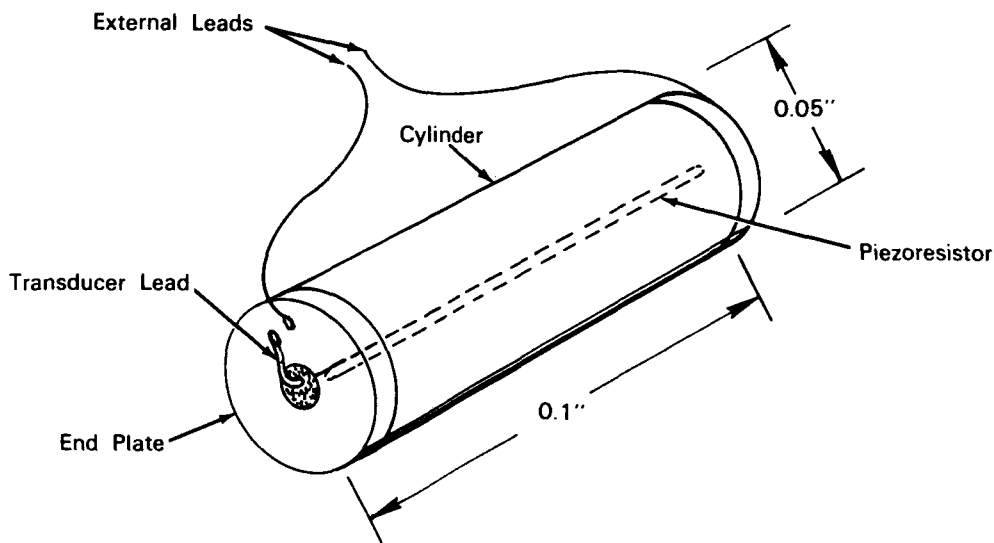
66-10484

NASA TECH BRIEF



NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

Miniature Stress Transducer Has Directional Capability



The problem: The measurement of stresses internal to a mass and, especially, along the direction in which they are oriented.

The solution: A miniature stress transducer that employs a semiconductive piezoresistive element that is stress sensitive along a specific axis only.

How it's done: A semiconductive transducer is fashioned from a p-type silicon splinter embedded in a centerless ground, high-density, polyethylene cylinder. The silicon splinter is a piezoresistor grown in a selected crystallographic orientation to possess piezoresistive characteristics along a selected axis. Brass end plates, drilled for the transducer leads, are fastened to the transducer cylinder ends using an epoxy adhesive. The assembly is held in a fixture while epoxy adhesive is injected into the cylinder to embed the silicon

splinter permanently. The transducer leads are resistance welded to the brass end plates that include external leads for connection to instrumentation.

The mechanism of measurement is based on the compressive deformation of the transducer. Loading of the transducer cylinder along the piezoresistor's sensitive axis changes resistance of the silicon splinter in direct relation to the amount of stress applied. Various deformation sensitivities are possible by using cylinders of differing Young's modulus.

Notes:

1. Other cylinder materials which exhibit the characteristics of homogeneous structure, low modulus, nonconductivity, ease of machining, and good bonding to the semiconductor crystal have been found to be suitable, e.g., etched teflon.

(continued overleaf)

2. Materials having poor bonding qualities, e.g., nylon, were found to be unsatisfactory.
3. A number of transducers may be readily mounted about a point region in a structural member, each aligned with a direction of interest, thereby obtaining multiaxial stress analysis of the point region.
4. This transducer would be useful for constant monitoring of stress in structural members of buildings, dams, etc.

5. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California, 91103
Reference: B65-10023

Patent status: NASA encourages the immediate commercial use of this invention. Inquiries about obtaining rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

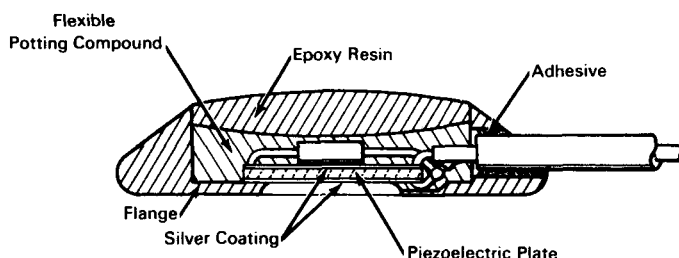
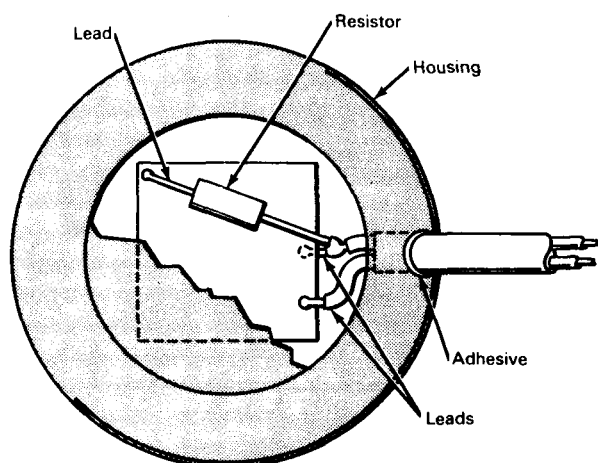
Source: Anthony San Miguel and
Robert H. Silver
(JPL-591)

NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Phonocardiograph Microphone Is Rugged and Moistureproof



The problem:

To design a microphone to be used as a phonocardiograph transducer under conditions such as experienced by an astronaut. The microphone must be capable of monitoring small amplitude audio signals in the presence of large shock loads, accelerations of up to 40g, temperatures from 30° to 200° F, and high humidity.

The solution:

A microphone incorporating a lead zirconate-lead titanate piezoelectric plate encapsulated in a flexible polyurethane resin contained in a sealed nylon case having a diameter of less than 1 inch.

How it's done:

A square plate (approximately 0.4 inch on a side) of the piezoelectric ceramic with a silver coating on opposite faces, to permit soldering of lead wires to the plate, is supported at diagonally opposite corners on a flange at the bottom of the nylon case. The

lead wires are soldered to the plate surfaces as shown in the illustration. A 470 Kohm (0.1 watt) carbon resistor, soldered in parallel with the terminals of the piezoelectric plate, serves to provide the required low frequency response of the transducer. The plate is secured to the support points on the flange by means of a suitable adhesive coating. This adhesive material is also used to seal the joints between the case and the cable.

The space directly above the plate is partially filled with a polyurethane resin, which, when cured, remains sufficiently flexible so as not to interfere with the piezoelectric characteristics of the plate. The polyurethane resin also holds the resistor in fixed relation to the plate and effectively seals the internal circuit against moisture in the atmosphere and from perspiration from the body to which the transducer is attached. The remainder of the cavity is filled with an epoxy resin, which, when cured, serves as an

(continued overleaf)

electrical and thermal insulator and exhibits high resistance to mechanical shock. This epoxy resin is also applied as a seal to the interface junction between the piezoelectric plate and the opening at the base of the transducer.

Notes:

1. In use, the base of the microphone is secured to the skin over the area to be monitored with a piece of double-backed surgical tape.

2. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
Houston, Texas 77058
Reference: B66-10314

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: William J. Young
(MSC-212)

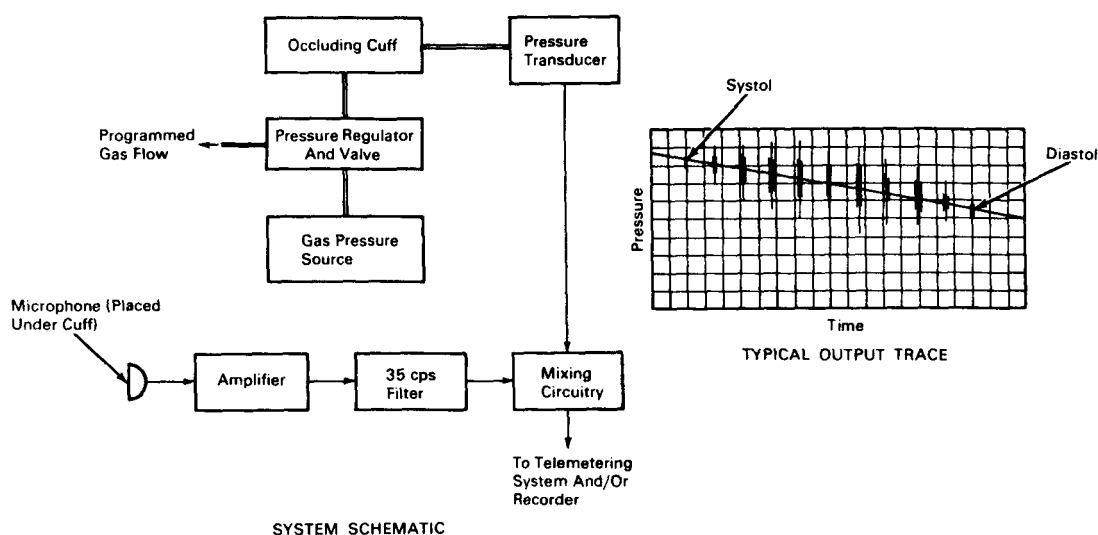


NASA TECH BRIEF



NASA Tech Briefs are issued by the Technology Utilization Division to summarize specific technical innovations derived from the space program. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia, 22151.

Blood-Pressure Measuring System Gives Accurate Graphic Output



The problem: To develop an instrument that will provide an external (indirect) measurement of arterial blood pressure in the form of an easily interpreted graphic trace that can be correlated with standard clinical blood-pressure measurements. From sphygmograms produced by conventional sphygmographs, it is very difficult to differentiate the systolic and diastolic blood-pressure pulses and to correlate these indices with the standard clinical values. It is nearly impossible to determine these indices when the subject is under physical or emotional stress.

The solution: An electronic blood-pressure system, basically similar to conventional auscultatory sphygmomanometers, employing a standard occluding cuff, a gas-pressure source, and a gas-pressure regulator and valve. An electrical output transducer senses

cuff pressure, and a microphone positioned on the brachial artery under the occluding cuff monitors the Korotkoff sounds from this artery. The output signals present the conventional systolic and diastolic indices in a clear, graphical display. The complete system also includes an electronic timer and cycle-control circuit.

How it's done: The output of the microphone is fed through a solid-state amplifier and a 35-cps filter into the mixing circuitry where it is superimposed on the signal from the pressure transducer. The output of the mixing circuitry is fed to a continuous chart recorder which gives a plot of cuff pressure versus time. The first signal pulse appearing on the graph as the cuff pressure is slowly reduced indicates the systolic pressure and the last pulse corresponds to the diastolic pressure.

(continued overleaf)

Notes:

1. The occluding cuff must be of a minimum width in order to ensure correlation of the measured systolic and diastolic values with the accepted indices. A narrow cuff is highly desirable for comfort and mobility of the subject.
2. Over 2,000 blood pressure measurements have been taken using this system on various individuals, and many of the readings have been compared with those taken with a conventional sphygmomanometer and stethoscope. In only a few instances were the readings off by more than a few millimeters of mercury.
3. A small amount of additional development would be required to make the system completely automatic. Such a system should be of considerable value for monitoring the blood pressure of hospitalized patients and as a clinical diagnostic aid.

4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Manned Spacecraft Center
P. O. Box 1537
Houston, Texas, 77001
Reference: B65-10365

Patent status: NASA encourages the immediate commercial use of this invention. It is owned by NASA and inquiries about obtaining royalty-free rights for its commercial use may be made to NASA, Code AGP, Washington, D.C., 20546.

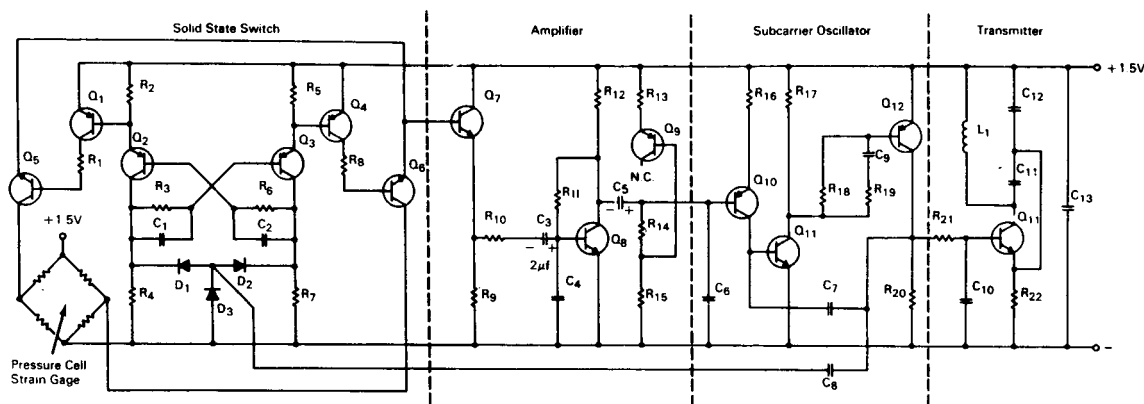
Source: The Garrett Corporation under contract
to Manned Spacecraft Center
(MSC-191)

NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Miniature Telemetry System Accurately Measures Pressure



The problem:

To design a telemetry system to accurately measure pressure with a small implantable pressure cell and transmitter. The system must operate with low power consumption.

The solution:

A miniature, low power, telemetry system that can be used with any of a number of commercially available strain gage pressure transducers. A small, solid state, strain gage pressure cell, designed for implanted physiological applications, is used with the new circuitry to provide a complete, implantable pressure transducing system.

How it's done:

The electronic circuit uses a pulse code modulation similar to ones previously used for temperature and biopotential monitoring. The subcarrier modulation technique allows accurate transmission of the low

output level of the pressure cell from an implanted location to a remote radio receiver. The small strain gage signal (approx. 15 mv for 250 mm of Hg) is chopped by means of a solid-state switch ($Q_1, Q_2, Q_3, Q_4, Q_5, Q_6$) and amplified by an ac amplifier Q_7 and Q_8 (gain approximately 5). After amplification the signal controls the period of an astable multivibrator ($Q_9, Q_{10}, Q_{11}, Q_{12}$) operating at approximately 1 kHz. The pulse derived from the astable multivibrator is applied through C_8 to obtain synchronous operation of the solid-state switch, thereby causing the period of the multivibrator to be controlled alternately by the voltage derived from Q_5 and Q_6 . The difference between successive periods then is proportional to the bridge unbalance signal and hence the pressure. The interval between pulses at bridge balance would be identical, but in order to avoid ambiguity the bridge is initially unbalanced in such a manner that one period remains smaller than the other over the

(continued overleaf)

entire operating pressure range. A typical modulation of ± 20 percent of the mean period is obtained for a pressure change of 250 mm of Hg.

The short pulse developed by the astable multivibrator (approx. 20 microsecond long) is used to turn on the rf oscillator, Q₁₃. L₁ is used both as a tank circuit inductor and as a transmitting antenna. Since the information is derived from the time period between rf pulses, amplitude and frequency changes in the rf link do not affect the accuracy. After the pulses are received on a commercial FM receiver (88-108 MHz) a suitable demodulator is used to obtain an analog signal.

The telemetry system is shown with a protective coating of elasticized silicone rubber applied. In this condition, the system is ready for implantation.

Notes:

1. The system has been used to date only with pressure transducers, but the circuit is equally applicable to any measurement using a strain gage sensor. The pressure transducer is commercially available.
2. The transducer used is 6.5 mm in diameter and 1 mm thick. The lead-in wires terminate on the back of the transducer in a package that is 3.5 mm in diameter by 4.5 mm long.

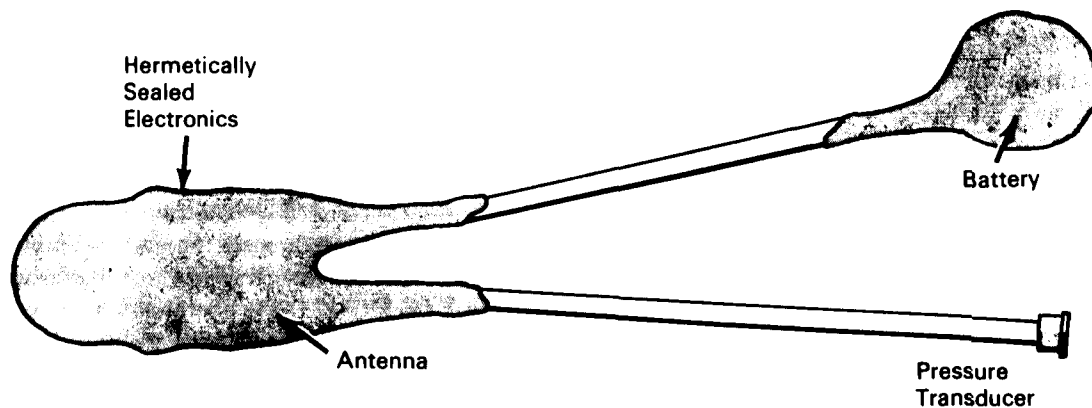
3. The compensated temperature range of the transducer is from 77°F to 113°F. The telemetering electronics are suitable for temperatures to 150°F.
4. The battery lifetime of 500 hours is associated with a transmission distance of 3 to 5 feet. Increased transmission distance will be accompanied by increased power consumption with a reduced battery life. It is estimated that the battery life would be reduced to 125 hours for a transmission distance of about 100 feet.
5. Similar applications are described in Tech Brief 64-10171 for biopotential monitoring and Tech Brief 66-10057 for temperature monitoring.
6. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Ames Research Center
Moffett Field, California 94035
Reference: B66-10624

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

Source: T. B. Fryer
(ARC-74)



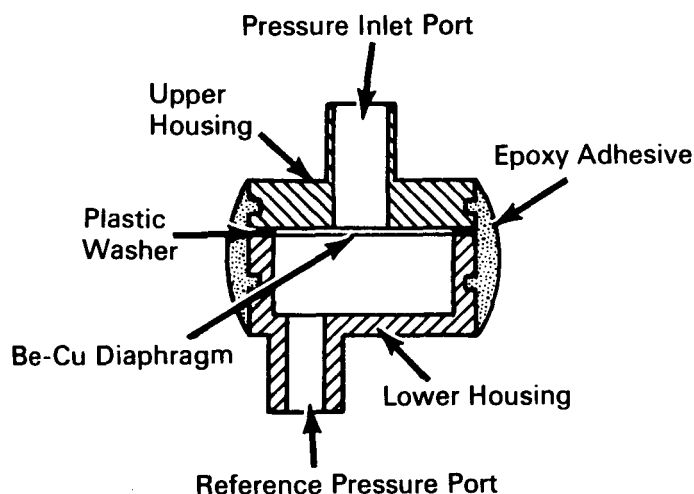
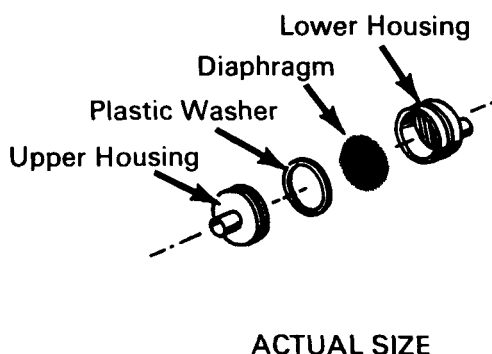
Miniature Telemetry System
Ready for Implantation

NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Miniature Capacitor Functions as Pressure Sensor



The problem:

To devise a miniature capacitor that will operate reliably as a differential-pressure telemetry sensor over wide ranges of pressure, temperature, and acceleration encountered during free flight of an instrumented test model in a hypersonic continuous-flow wind tunnel.

The solution:

A capacitor incorporating a beryllium copper diaphragm that produces a variation in capacitance as a function of the pressure applied to one face of the diaphragm relative to a reference pressure applied to the opposite face.

How it's done:

The actual size of the unit (exploded view) and the construction details (sectional view) are shown in the illustrations. The diaphragm is secured to the rim of the lower housing by means of a low-melting solder in a specially designed fixture. This subassembly and

electrically insulating washer are then fitted to the upper housing and aligned in another specially designed fixture. An epoxy adhesive is used to hold the assembly together and provide a pressure seal at the seam.

When the respective pressures are applied to the inlet and reference ports, the diaphragm moves slightly and correspondingly changes the capacitance of the unit in response to the pressure difference. The capacitance is measured between the upper and lower housings connected to the tank circuit of a telemetry oscillator.

Notes:

1. The capacitor is capable of withstanding an over-pressure of 50 psi and is insensitive to the accelerations and temperatures encountered in a hypersonic wind tunnel. It may also be used as an absolute pressure sensor by sealing the reference port.

(continued overleaf)

2. The units can be easily produced within close capacitance tolerances using the specially designed assembly fixtures.
3. Capacitors of this design can be used for remote measurement of rapid as well as slow changes in pressure in a variety of applications.
4. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
Reference: B67-10020

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

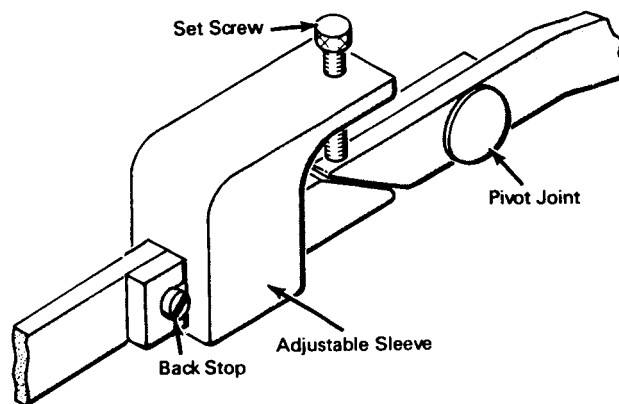
Source: R. G. Harrison
(JPL -903)

NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Adjustable Hinge Permits Movement of Knee in Plaster Cast



ADJUSTABLE KNEE HINGE IN LOCKED POSITION

The problem:

To design an adjustable metal knee hinge to be installed in a plastic leg cast to facilitate movement of the knee joint. The knee hinge should help eliminate stiffness of the knee that results from the use of a solid cast. Prior art used a knee hinge of flat stock material that was bulky and difficult to adjust.

The solution:

A metal knee hinge with an adjustable sleeve to be worn on the outside of a leg cast.

How it's done:

The metal knee hinge is equipped with an adjustable sleeve that can be slipped over the pivot joint to lock the brace into an immovable position. The sleeve can also be slid back to a stop pin where a degree of movement is allowed. The extent of allowable movement or travel is determined by the setting of a set screw that is mounted in the top of the adjustable sleeve. The screw can be adjusted to allow approximately 35° of travel from the locked position. The other knee hinge on the inner side of the leg cast is

equipped with a straight sleeve as utilized in most braces.

Notes:

1. The position setting of the hinge can be manipulated through most trouser materials, eliminating the necessity of removing or slitting the trousers.
2. When the cast can be hinged at the knee it affords greater comfort while sitting and should allow for better circulation in the leg.
3. Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B67-10056

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

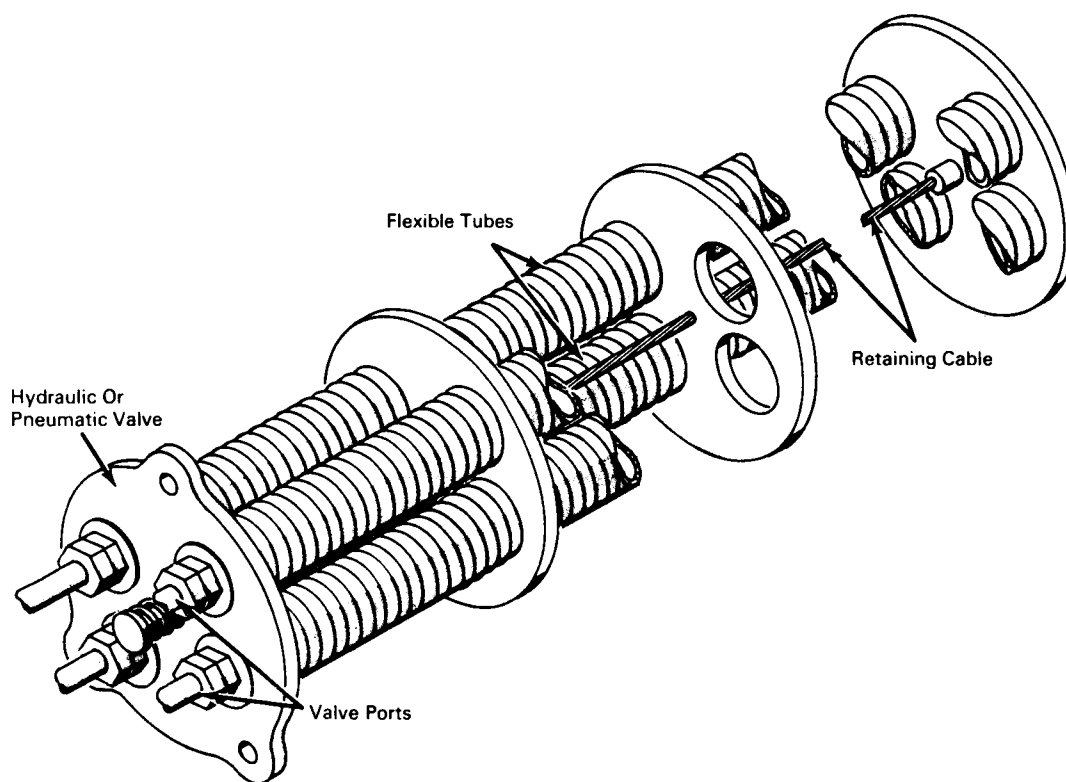
Source: William E. Maley
(M-FS-1756)
Category 04

NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U.S. space program, to encourage their commercial application. Copies are available to the public at 15 cents each from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Hydraulically Controlled Flexible Arm Can Bend in Any Direction



The problem:

To design a flexible arm that can bend in any direction.

The solution:

An arm assembly consisting of four flexible tubes controlled by a four-way hydraulic or pneumatic valve.

How it's done:

Positioning of the flexible arm is controlled by a four-way hydraulic or pneumatic valve. Each port of

the valve is connected to one of the four flexible tubes of the arm. Fluid, under pressure, is routed through the valve ports to the tubes. When equal pressure is applied to the tubes, they expand equally and become rigid. When different pressures are applied to the tubes, unequal expansion results and the arm bends. The retainer cable, which is in a state of tension, restrains tube expansion, maintaining equilibrium. By varying the pressure through the valve ports, the flexible arm can be bent in any desired direction.

(continued overleaf)

Notes:

1. The flexible arm could be used for probing areas that cannot be reached by ordinary tools, handling hazardous materials, as a search mount for radar antennas, and for graph recording.
2. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Kennedy Space Center
Kennedy Space Center, Florida 32899
Reference: B66-10626

Patent status:

No patent action is contemplated by NASA.

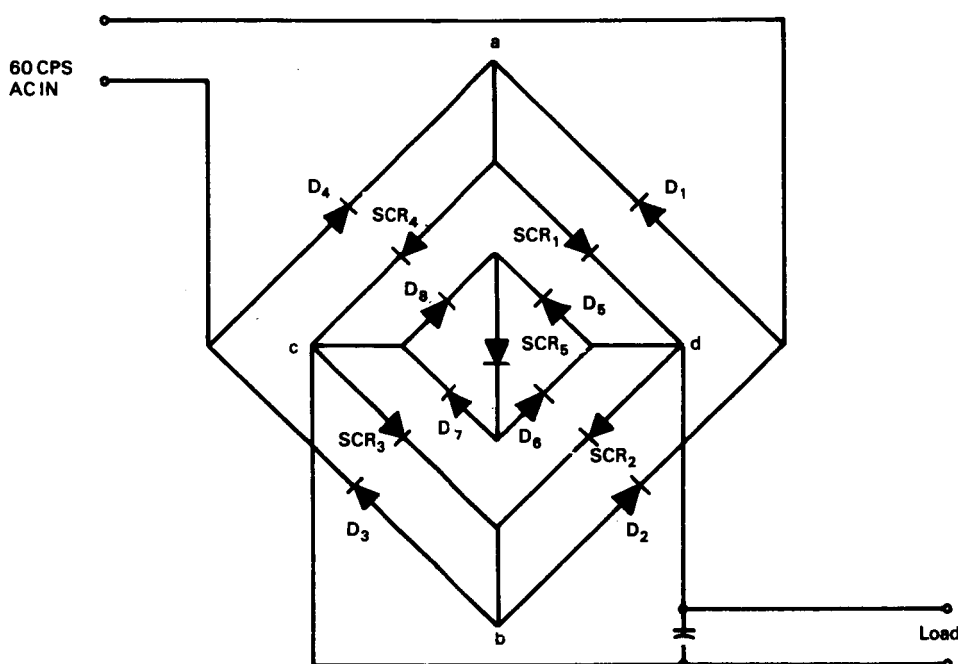
Source: F. D. Griffin
(KSC-66-20)

NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Solid State Circuit Controls Direction, Speed, and Braking of DC Motor



The problem:

Various solid state devices are used to control the speed of dc motors, but do not provide for reversing or braking which are required for accurate positional control of large inertial loads.

The solution:

A full-wave bridge rectifier circuit in which the gating of silicon controlled rectifiers (SCR's) controls output polarity. Braking is provided by an SCR that is gated to short circuit the reverse voltage generated by reversal of motor rotation.

How it's done:

Diodes D₁ through D₄ form a conventional full-wave bridge providing full-wave pulsating dc voltage between points a (positive) and b (negative). Point a is connected to a bridge consisting of SCR₁ through SCR₄. By gating SCR₁ and SCR₃, an external load will see point d positive with respect to point c. If SCR₂ and SCR₄ are gated, the opposite condition will exist. Braking is accomplished by gating SCR₅ after removal of the gate signals from SCR₁ through SCR₄. SCR₅ then short circuits the voltage generated by the armature rotation. The capacitor keeps voltage transients from misfiring the SCR's.

(continued overleaf)

Note:

Inquiries concerning this invention may be directed to:

Technology Utilization Officer
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, California 91103
Reference: B66-10486

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

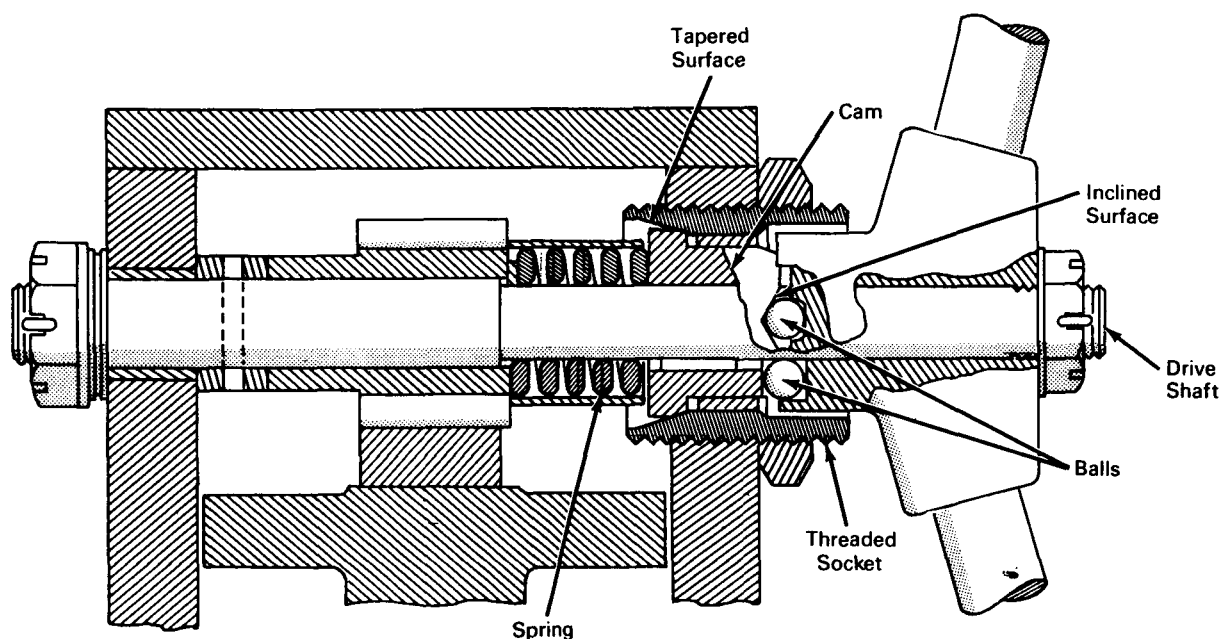
Source: Michael F. Hanna
(JPL-757)

NASA TECH BRIEF



NASA Tech Briefs are issued to summarize specific innovations derived from the U. S. space program and to encourage their commercial application. Copies are available to the public from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151.

Braking Mechanism Is Self Actuating and Bidirectional



The problem:

It is desired to effect a braking action on a moving item of equipment, in either direction of motion, immediately upon removal of the driving force and with no human operator involvement.

The solution:

A mechanism that automatically applies braking force, regardless of the driving force direction, and permits no coasting.

How it's done:

In operation, driving torque is applied in either direction of rotation to the drive shaft. Rotation of the drive shaft causes the balls that are seated against the cam to ride slightly up the cam surface, depressing the

spring and thus forcing the tapered surface of the cam away from the mating surface of the threaded socket. The shaft is now free to turn so long as a constant driving force is applied to it. Upon removal of the driving force, the balls return to their original seats against the cam and release the spring which causes the mating surfaces of the cam and threaded socket to re-engage, thereby producing immediate braking action.

Notes:

1. This device would be useful wherever free movement is undesirable after an object has been guided into a precise position. It could be used for precise control of the raising and lowering of objects on a chain hoist.

(continued overleaf)

2. The automatic brake could be used on wheeled equipment operating on slopes in circumstances that can not tolerate slippage.
3. Inquiries concerning this innovation may be directed to:

Technology Utilization Officer
Marshall Space Flight Center
Huntsville, Alabama 35812
Reference: B66-10484

Patent status:

No patent action is contemplated by NASA.

Source: Joseph Pizzo
of North American Aviation, Inc.
under contract to
Marshall Space Flight Center
(M-FS-1299)

Mr. J. Chris Floyd
Bldg. E-108
Wallops Station
Wallops Island, Virginia 23337

Mr. Ernest Burciaga
Western Support Office
150 Pico Boulevard
Santa Monica, California 90406

Mr. Harry Haraseyko
NASA Headquarters
Code UTA
Washington, D. C. 20546

Dr. Joseph W. Ehrenreich
Director
Research Institute for Business
and Economics
Graduate School of Business
Administration
University of Southern California
Los Angeles, California 90007

Dr. Robert O. Harvey
Dean, School of Business Administration
University of Connecticut
Storrs, Connecticut 06268

Dr. Howard L. Timms
Co-Director
Aerospace Research Applications Center
Indiana University Foundation
Bloomington, Indiana 47405

Dr. R. Jones
Director, Center for Application
of Sciences and Technology
Wayne State University
Detroit, Michigan 48202

Mr. Philip Wright
Director, Office of
Industrial Applications
University of Maryland
7100 Baltimore Avenue
College Park, Maryland 20740

Dr. Allen Kent
Director, Knowledge Availability
Systems Center
University of Pittsburgh
Pittsburgh, Pennsylvania 15213

Mr. Peter J. Chenery
North Carolina Science and
Technology Research Center
P. O. Box 12235
Research Triangle Park,
North Carolina 27709

Mr. Lee Zink
Director, Technology Use
Studies Center
Southeastern State College
Durant, Oklahoma 74701

Mr. William A. Shinnick
Director, Technology
Application Center
Bureau of Business Research
University of New Mexico
Albuquerque, New Mexico 87106

Dr. Ray Ware
Southwest Research Institute
8500 Culebra Road
San Antonio, Texas 78206

Dr. James Brown
Research Triangle Institute
P. O. Box 12194
Durham, North Carolina 27709

Dr. S. N. Stein
Chief, Medical Office
NASA Ames Research Center
Moffett Field
Mountain View, California 94035

Technology Utilization Office
National Aeronautics and Space
Administration
George C. Marshall Space Flight Center
Huntsville, Alabama 35812
Attn: Mr. David Winslow

Northwestern University
Biomedical Instrumentation Labs
303 E. Chicago Avenue
Chicago, Illinois
Attn: Mr. M. L. Petrovick, Manager

Dr. Harry Ludwig, Director
Medical Electronics Laboratory
The University of Wisconsin
Medical Center
Room 88, Medical Sciences Building
Madison, Wisconsin 53706

Dr. James B. Reswick
Director, Engineering Design Center
Case Institute of Technology
University Circle
Cleveland, Ohio 44106

Mr. George Edwards
Mail Stop N-240-2
Ames Research Center
Moffett Field
Mountain View, California 94035

Mr. Sam Snyder
Mail Stop F-309
Space Nuclear Propulsion Office
Technology Utilization Branch
U.S.A.E.C. Bldg.
Germantown, Maryland 20545

Mr. James T. Dennison
Electronics Research Center
575 Technology Square
Cambridge, Massachusetts 02139

Mr. Clinton T. Johnson
Box 273
Flight Research Center
Edwards, California 93523

Mr. John F. Stokes
Code 206
Goddard Space Flight Center
Greenbelt, Maryland 20771

Mr. John H. Drane
NASA Pasadena Office
4800 Oak Grove Drive
Pasadena, California 91103

Mr. James O. Harrell
Code GA-P
John F. Kennedy Space Center
Kennedy Space Center, Florida
32899

Mr. Charles Shufflebarger
Langley Research Center
Langley Station
Hampton, Virginia 23365

Mr. Paul Foster
Lewis Research Center
21000 Brookpark Road
Cleveland, Ohio 44135

Mr. John T. Wheeler
Code BM-5
Manned Spacecraft Center
Houston, Texas 77001

Mr. James Wiggins
Code MS-T
George C. Marshall Space Flight
Center
Huntsville, Alabama 35812